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Water Reuse and Wastewater Recycling at U.S. Army Installations

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Construction Engineering Research Laboratory

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Abstract: In the future, some U.S. Army installations may face water shortages resulting from climate change, drought, reduced surface streams and aquifer levels, competing regional requirements for agriculture, municipal consumption, energy production, and environmental requirements. This reduction in available water resources will threaten the Army's ability to execute its mission. Many Federal, Department of Defense (DOD), and Army policies, regulations, plans, and strategies have sought to address this problem by encouraging water conservation, efficiency, and reuse. Many states also promote or require water reuse. Where practical, the Army promotes and practices water reuse in a numerous ways, e.g., for irrigation, aquifer recharge, cooling tower makeup, environmental purposes, vehicle washing, and industrial uses. Despite these efforts, Army water consumption is not decreasing. Water reuse and wastewater recycling are ways to reduce scarcity problems and reduce use of potable water. There is a need for additional ways, including policy changes, to encourage these conservation practices. This report explores current and potential water reuse and wastewater recycling in the Army (including applicable laws and regulations, differences between regulations and guidelines, potable reuse considerations, and examples of water reuse at installations), and makes recommendations for policy changes that will increase water reuse on Army installations.

Table of Contents

Preface

This study was conducted for the Army Environmental Policy Institute (AEPI) under Work Unit K39515, "Evaluate and Recommend Water Reuse Policies within the Army." The technical monitor was Dr. Marc Kodack, Senior Fellow, AEPI.

The work was managed and executed by the Environmental processes Branch (CN-E) of the Division (CN), U.S. Army Corps of Engineers, Construction Engineering Research Laboratory (CERL). The CERL principal investigator was Richard J. Scholze. Appreciation is owed to William Eng (Office of the Assistant Chief of Staff for Installation Management [OACSIM]) for technical review and input. Appreciation is also extended to William Fifty and Todd Richards, of the U.S. Army Public Health Command. Deborah Curtin is Chief, CN-E, and Dr. John T. Bandy is Chief, CN. The associated Technical Director was Alan B. Anderson. The Deputy Director of CERL is Dr. Kirankumar V. Topudurti, and the Director is Dr. Ilker R. Adiguzel.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL Kevin J. Wilson, and the Director of ERDC is Dr. Jeffery P. Holland.

1 Introduction

Background

In the future, some U.S. Army installations may face water shortages resulting from climate change, drought, reduced surface streams and aquifer levels, competing regional requirements for agriculture, municipal consumption, energy production, and environmental requirements. Issues affecting water supplies include current/future availability, affordability, sustainability, quality, and security. This anticipated reduction in available water resources may limit the Army's ability to execute its mission. One essential way to alleviate water scarcity and reduce the use of potable water is through water reuse and wastewater recycling. This is not a new concept. The Army already uses recycled wastewater for irrigation, dust control, and vehicle washing. Other water recycling and reuse strategies are under development. One national movement, led by states such California and Texas, injects surface runoff and highly treated wastewater directly into aquifers or source intakes and then extracts water for processing through a potable water treatment plant.

The Army is a key water resource user that is also under the influence of tremendous geopolitical, economic, and strategic variables. To sustain its mission and ensure its capability to generate, train, project, and support its forces, the Army must anticipate, plan and mitigate the effects from anticipated economic and logistical water-related problems. This will require a transition to modern, secure, and efficient water systems; to improved management practices; and to highly efficient and environmentally friendly facilities and technologies.

Issues affecting water supplies are those of current and future availability, affordability, sustainability, quality, and security. Overcoming these supply and demand-side challenges will require effective planning and execution using integrated solutions. This work was undertaken to help chart an effective and viable path for the Army's future water use, one that considers the short and long-term issues involved in developing enduring policies and solutions.

Objectives

The objective of this work was to investigate current and potential water reuse and wastewater recycling in the Army, and to make recommendations for policy changes that will increase water recycling and reuse on Army installations.

Approach

Water reuse policy in general is addressed on a state-by-state basis as geography and climate are the primary determinants of the importance of water to a region. Secondary determinants are population, local economy, industry, agriculture, energy production, and environmental considerations. This report reviews available guidance, policies, regulations, and laws affecting water reuse policy at the Federal, U.S. Department of Defense (DOD), and Army level.

This report describes water reuse activities currently in practice within Army installations and opportunities to increase the amount of water that is reused. Potable water reuse is an emerging area receiving consideration although significant political, scientific, and technological variables remain unresolved. Recommendations are made to increase the amount of water reuse on the Army to meet goals from numerous applicable regulations, legislation and policies. Some policies may need to be modified to encourage a higher level of water reuse.

Mode of technology transfer

This report will be made accessible through the World Wide Web (WWW) at URL: http://www.cecer.army.mil

Definitions

The discussion of water reuse first requires some baseline definitions (Table 1).

Table 1. Water reuse terminology.

Term	Definition
Blackwater	Water captured from toilets and urinals along with kitchen waste.
Direct potable reuse	The introduction of highly treated reclaimed water either directly into the potable water supply distribution system downstream of a water treatment plant or into the raw water supply immediately upstream of a water treatment plant.
Graywater*	Water captured from sinks, baths, showers, and residential laundries that can be treated and reused. It does not include water from kitchen sinks or dishwashers.
Indirect potable reuse	The planned incorporation of reclaimed water into a raw water supply, such as in potable water storage reservoirs or groundwater aquifer, resulting in mixing and assimilation, thus providing an environmental buffer.
Rainwater harvesting	Runoff captured from rooftops or other hard surfaces that can then be used for beneficial use after minimal treatment.
Reclaimed water	Municipal wastewater that has gone through various treatment processes to meet specific water quality criteria with the intent of being used in a beneficial manner such as irrigation. The term recycled water is often used synonymously with reclaimed water.
Wastewater	Used water discharged from homes, businesses, and industry.
Water reuse	The use of treated wastewater for a beneficial use, such as irrigation or industrial cooling.

* Some organizations do accept a definition of “graywater” that does include kitchen and dishwasher wastewater along with wastewater from soiled diaper washing. This graywater has higher levels of risk.

2 Water Issues

Availability

Water scarcity is a greatly underestimated resource issue. World water use has tripled in the past 50 years (WWAP 2009). Forty percent of the world food supply now comes from irrigated lands, partly because the world food economy increasingly relies on irrigation (Advameg 2011, Postel 1999). While the demand for water continues to rise, the amount of fresh water supply provided by the hydrologic cycle remains relatively constant. Consequently, aquifers are increasingly stressed (i.e., more water is extracted than is replaced).

Affordability

For most U.S. citizens and the Army, water remains a very affordable commodity, especially for non-irrigation needs. Water availability, its price, its value, and its actual costs vary considerable by region. In many areas of the United States, water and wastewater treatment rates are rising faster than energy costs, especially in the arid West and in parts of the east coast. In regions with abundant water supplies and low commodity costs, Army installations have fewer economic incentives to use the water wisely or efficiently.

Sustainability

Sustainability to the DOD is the ability to operate into the future without decline in the mission or the natural and manufactured systems that support it. One of the Strategic Sustainability Performance Plan’s goals is to improve water resource management. This goal is complicated when, in any given area, growing populations increase the demand for water. This increased demand can burden water supplies that are naturally replenished by a relatively static (limited) hydrologic cycle. Climate change effects can further limit the recharging of water supplies. This trend of growing water consumption from a fixed or decreasing water supply is unsustainable, as evidenced by declining water table levels in many parts of the country and world, particularly in the western United States. One option to address this problem is more efficient use (and reuse) of water.

Quality

In addition to quantity, water quality is a vital consideration. For example, Fort Bliss, which was faced with a diminishing water supply, had access to plenty of brackish water. The installation entered into a joint project with the City of El Paso, Texas to build a desalination plant on Fort Bliss although the energy requirements of the desalination plant may make use of the facility costly to operate. At Fort Irwin, California, the water supply has naturally occurring arsenic, which requires additional levels of treatment before it can be used as potable water.

Security

Secure water supplies are critical for an installation's mission. Unlike energy, world market pressures do not affect the supply or cost of water, but like energy, water supplies can be vulnerable to infrastructure threats. Vulnerability assessments have revealed that water systems are threatened by chemical or bioterrorism attacks (HR 3448 2002). Another concern is the effect of privatization. When private companies operate public water distribution systems, their stocks may be publicly traded. If one or more of these companies were to fail, that failure could disrupt the water systems that the company manages and ultimately affect the water supply. Sharing water sources with non-installation entities might affect the ability of the installation to continue to meet its mission if the supply cannot meet future demand of both the installation and non-installation populations.

Water trends

Facility consumption dominates Army water consumption. Careful planning and implementation of water conservation/water efficiency technologies and practices, including water reuse technologies, can decrease consumption of potable water in the Army. There is considerable cost-effective and untapped potential for saving potable water through minimizing wasteful practices, water conservation, and reuse. To most effectively implement water conservation and water efficiency practices, water needs to be as highly valued as energy in the Army. Getting maximum efficiency from an available water supply and using water which would normally be discarded will enable the Army installations to meet its long-term sustainability goals and show immediate reductions in water consumption.

Costs for water and sewage continue to rise. Potential mission shifting or increased growth may be unattainable because of water restrictions or water unavailability. Improved water efficiency of existing consumptive water

uses will enable the Army to become more sustainable, be good neighbors in water-short areas, reduce environmental effects, reduce costs and sustain their mission.

On an Army installation, the Directorate of Public Works has responsibility for Army real estate including utilities and water supply. This includes master planning, construction and operation and maintenance. On many installations, however, there has been a push to privatize utilities and consider water and wastewater service from local providers or contract services, effectively raising rates.

3 The Regulatory Environment

A number of Federal, Department of Defense, and Army policies encourage water conservation, efficiency, and reuse. These include the various iterations of Energy Policy Acts that required reductions in water use intensity across the Army and Federal agencies, as well as other policies. These policies are:

- Sustainability plans of individual military installations
- The Army Sustainability Campaign Plan (HQDA 2010)
- DOD Strategic Sustainability Performance Plan (DOD 2010)
- Army Environmental Policy such as AR 200-1
- Army Strategy for the Environment (ASAIE 2004)
- Executive Order (EO) 13423 (White House 2007)
- EO 13514 (White House 2009)
- Best management practices for water conservation promulgated by the Federal Energy Management Program (FEMP)
- The Federal Green Building Initiative
- Requirements for Army Projects for new construction to comply with Low Impact Development guidelines and a requirement that any new construction projects must achieve Leadership in Energy and Environmental Design–New Construction (LEED-NC) Silver Rating.

The most recent of these policy instruments is EO 13514, which requires a 2 percent annual reduction in potable water use for a total of 26 percent by 2020 using a 2007 baseline for Army installations. Additional reductions are mandated in irrigation, and in agricultural and industrial consumption. These are only a few of the many requirements that stress water efficiency and promote water reuse throughout the Army and Federal government. Many states have also issued additional policies promoting, requiring, and encouraging water reuse.

AR 200-1 states that all Army organizations and activities will comply with applicable Federal, state, and local environmental laws, regulations, and EOs. While most environmental laws apply to the Army, some include exemptions (or provisions for requesting exemptions) for military activities under certain conditions. It is essential that Army counsel be consulted on the applicability of all laws, regulations, initiatives, and EOs.

Regulatory compliance

Planning for regulatory compliance includes evaluation of Federal, state and local laws, regulations, and policies that may affect a proposed water reuse project. A water reuse project of this complexity is usually presented as a wastewater reclamation facility that will provide reclaimed water for beneficial use. On a smaller scale, such as rainwater harvesting for an individual building, state and local regulation may apply (U.S. Army Corps of Engineers 2010). In other cases, minimal constraints exist. State and local regulatory controls may include:

- state and local water reclamation and reuse regulations or guidelines
- source control regulations
- state-mandated reuse
- state or local ordinances
- anti-degradation laws
- permitting and reporting regulations
- cross-connection control regulations.

Project proponents then contact the regulatory authority (ies) responsible for water reclamation and reuse regulations, e.g., the Department of Health, Department of Environmental Protection, Department of Environmental Quality, and/or Department of Water Resources. These agencies may/will vary between states. In some states, the state agency having the authority and responsibility to develop and adopt water reuse regulations may be different from the state agency that enforces those regulations. Some states issue permits through the National Pollutant Discharge Elimination System process. Regardless of which state agency has the authority to adopt and enforce water regulations, state and local health departments may have additional regulations affecting water reuse that must be followed, such as regulations addressing the separation of potable water lines and reclaimed distribution lines, cross-connection control regulations, or other standards to protect potable water supplies.

Some of the Federal laws and regulations to consider, several of which have been delegated to the states or have been adopted in modified form by the states, include:

- National Environmental Policy Act of 1969
- Federal Clean Water Act
- Safe Drinking Water Act (SDWA)
- Endangered Species Act
- National Pollutant Discharge Elimination System
- Underground Injection Control Program.

Additional considerations include water rights and codes such as:

- Prior appropriation and/or regulated riparian rights
- Uniform Plumbing Code
- Uniform Building Code.

The following sections summarize and exemplify Federal requirements that may affect the planning and implementation of water reuse projects.

Water rights

The two basic types of surface water rights in the United States are riparian and prior appropriation water rights, either of which may directly or indirectly affect water reuse activities. Riparian water rights, found mostly in eastern states, link the use of water to the ownership of the land adjacent to that water body. The prior appropriation doctrine, used mainly in western states, allocates water on the basis of seniority or "first in time, first in right" and is not related to the property's proximity to the water source.

Water rights can indirectly affect the acceptability of water reuse by either constraining or encouraging the use of reclaimed water. For example, a wastewater discharger may not be allowed to reduce the discharge of wastewater to a watercourse or change the point of discharge or point of use and, therefore, not be allowed to reuse its wastewater. Conversely, water rights provisions that prevent increased water withdrawals generally encourage the use of reclaimed water to meet existing or future water needs. A use hierarchy still exists in both riparian and prior appropriation law. During water shortages it is possible that a more senior use could make claims on reclaimed water (U.S. Environmental Protection Agency 2004). A memorandum on policy guidance on Army installation (Stockdale and Johnson 1995) that set policy and instructions on how water rights information would be documented and protected on Army installations in the United States.

During the planning phase of a water reuse project, it is important to determine who among the discharger, water supplier, other appropriators, or environmental interests owns the right to use reclaimed water. In California, for example, the wastewater treatment agency has exclusive rights to the reclaimed water until it is discharged to a receiving water unless otherwise provided by agreement (Cologne and MacLaggan 1998).

Federal, state, or local laws or policies may affect the desirability of water reuse. An example of this is the "return flow credits" concept along the Colorado River. Nevada's right to Colorado River water is based on consumptive allocation. That is, for every gallon of treated wastewater that originated from the river and that is returned to the river, an equal quantity of water above the basic allotment can be withdrawn and treated for potable use. Water that is not returned to the river is charged against Nevada's allocation. Thus, since the volume of treated wastewater that originated from the river can be credited toward additional potable use, no additional supply is available by using reclaimed water for irrigation or other consumptive uses (Crook 2004). In this case, to access additional water supply, reused water cannot come from the local potable water system.

While most water rights issues are determined by state law, there are some Federal laws that may affect the planning of water reuse projects. This may occur when the project affects the water supply of more than one state, of Federally recognized Native American tribes, or of Canada or Mexico. The Federal government also has the right to adequate water from sources on or adjacent to its own property to meet the required needs of the land. Additionally, many military installations in the western states have senior water rights dating back to the installation's establishment.

Groundwater rights vary from state-to-state and may even vary within states. Different groundwater use rights include correlative rights to withdraw water from beneath the land for beneficial uses on the land, use of the prior appropriation doctrine, requirement of permits for withdrawal and protection of other uses from excessive withdrawals, or unlimited access to the resource by permitted landowners. Some states regulate groundwater regionally through critical area designations or other means, with more stringent controls in some regions than in other. Other rights may relate to managing stored water, excluding others from capturing it, or transferring stored water to other agencies or jurisdictions (National Resource Council 2008). Thus, water rights associated with groundwater recharge projects are more likely to directly affect a water reuse project than are other applications of reclaimed water. It is important to investigate and understand such laws and regulations early in the project planning.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) mandates an assessment and mitigation of environmental impacts caused by Federal projects such as water reuse projects depending on their scope. It also mandates that there

be an opportunity for public input during all stages of the environmental assessment process, including initial identification of project objectives and formulation of alternatives to be analyzed. If significant impacts are identified, NEPA requires Federal agencies to complete an environmental impact statement, which must include an analysis of impacts associated with alternative projects and identification of mitigation measures to be implemented. While NEPA specifically addresses Federal projects, many states have passed similar laws that apply to state and local programs.

Clean Water Act

The Federal Clean Water Act (33 U.S.C. 1251–1376;) requires states to set water quality standards. While primary jurisdiction under the Clean Water Act is with the U.S. Environmental Protection Agency, the Clean Water Act is administered and enforced in most states by the state water pollution control agencies. Wastewater discharge regulations principally address treated effluent quality, specifically the removal of biological and chemical pollutants that could have a deleterious effect on receiving waters and may include total maximum daily load limits. Discharge permits may also restrict the quantity of effluent discharged to receiving waters to limit effects on local ecosystems. Permits are issued pursuant to the National Pollutant Discharge Elimination System. The Clean Water Act mandates that states develop and implement waste treatment management plants and practices on an area-wide basis that address regional water quality concerns and needs, apply best practicable waste treatment technology before any discharge into receiving water, including reclaiming and recycling of water, and confine disposal of pollutants so they will not migrate to cause water or other environmental pollution.

Safe Drinking Water Act

The Safe Water Drinking Act (SWDA) ensures that public water systems meet minimum standards for the protection of public health. The SDWA directly affects potable reuse projects and indirectly affects nonpotable reuse projects where reclaimed water ultimately may reach surface waters or groundwater used as a source of potable supply. For example, the management and regulation of aquifer storage and recovery wells fall under the Underground Injection Control program authorized by SDWA. In some cases, state drinking water regulations are more restrictive than the Federal regulations.

Water efficiency standards currently in effect were established in the Energy Policy Act (EPAct) of 1992. EPAct 2005 did not strengthen water management provisions of EPAct 1992 that are applicable to Federal facilities.

On Army installations, construction policy requires that plumbing fixtures, including toilets, urinals, faucets, and showerheads, shall meet or exceed the performance requirements of EPAct 1992, as amended, in all new construction and major renovations. This criteria will meet Leadership in Energy and Environmental Design – New Construction (LEED-NC) 2.2 water Efficiency Credit C 3.2. criteria.

Existing buildings require that all domestic fixtures shall be replaced to meet provisions of EPAct 1992, as amended, with a simple payback of 10 years or less. In drought or water imperiled areas, maximum payback periods of 15 years may be used for water conservation projects.

However, currently available devices that are more efficient than the minimum required ought to be required for new military construction. For example, current fixtures that exceed EPAct standards are 1.0 gallon per flush pressure assisted toilets, 0.5 gallon per flush urinals (1-pint urinals are currently available), waterless urinals, composting toilets, ultra-low flow faucets, and showerheads that have a flow rate less than 1.8 gallon per minute. The USEPA's WaterSense program (U.S. Environmental Protection Agency 2008) lists fixtures and appliances that exceed current values by at least 20 percent in water efficiency with hundreds of options. For clothes washers, these include horizontal axis washers and newer, Energy Star-rated* toploading units.

One recent Federal guidance driver was EO 13423, "Strengthening Federal Environmental, Energy and Transportation Management" (White House 2007). EO 13423 sets goals for agencies to implement practices to reduce potable water consumption intensity, relative to an fiscal year 2007 (FY07) baseline of an agency's consumption, by 2 percent annually through the end of FY15, or 16 percent by the end of FY15. Federal guidance was developed by the U.S. Department of Energy (USDOE) to assist in interpretation and guidance of EO 13423. The guidance directed each agency to reduce water consumption intensity, relative to the baseline of the agency's water consumption.

* A rating program of the USEPA and USDOE that encourages the use of water-efficient and energy-efficient fixtures and appliances, see http://www.energystar.gov/index.cfm?c=about.ab_index

EO 13423 also directed Federal sites to conduct water audits of at least 10 percent of facility square footage annually, and to conduct audits at least every 10 years. This requirement was superseded by the 2007 Energy Independence and Security Act (EISA) section 432 (Congress 2007), which requires energy and water evaluation of 25 percent of facilities every year. Federal agencies are also encouraged to purchase water efficient products and services, including WaterSense labeled products.

It should be noted that the requirements under EO 13423 superseded the requirements in EO 13123, namely the development of Water Management Plans and the implementation of the FEMP Water Efficiency Best Management Practices (USDOE 2010). The U.S. Department of Energy established Federal Best Management Practices (BMPs) — under FEMP — in response to requirements set forth in EO 13123, "Greening the Government Through Efficient Energy Management" (White House 1999) which required Federal agencies to reduce water use through cost-effective water efficiency improvements. However, agencies were encouraged to use these existing tools, which have since been updated to achieve the goals of EO 13423.

EO 13514, "Federal Leadership in Environmental, Energy, and Economic Performance" (October 2009) expands the water efficiency requirements of EO 13423 and EISA. (It does not supersede either.) It sets goals for agencies to:

- Reduce potable water consumption intensity by 2 percent annually through FY20, or FY26 percent by the end of FY20, relative to a baseline of the agency's water consumption in FY07, by implementing water management strategies including water-efficient and low-flow fixtures and efficient cooling towers.
- Reduce agency industrial, landscaping, and agricultural water consumption by 2 percent annually or 20 percent by the end of FY20, relative to a baseline of the agency's industrial, landscaping, and agricultural water consumption in FY10. The intent is to expand the water reduction of Federal agencies to include other areas of fresh water consumptions beyond potable water (USDOE 2010).

While EO 13514 strengthens the requirement for potable water; it also creates a new requirement for non-potable water that can be difficult to measure because of the absence of a comprehensive Army-wide facility water metering program. Specifically, EO 13514 identified and presented three key elements of compliance:

1. *Water Use Intensity Baseline Development*. Agencies must develop a water use intensity baseline (defined as gallons per gross square foot of facility space) for water used in FY07.
2. *Reduction in Water Use Intensity*. Agencies must identify and implement life-cycle cost-effective water savings measures to achieve, at a minimum, a 2 percent annual reduction or 16 percent overall reduction of water use intensity (gallons per total gross square footage of facility space) in agency facilities by the end of FY15.
3. *Reporting*. Agencies are required to report annual water use and facility gross square feet.

Policies

Army policy on water reuse

The following policies currently exist:

- Army Regulation (AR) 420-1 (Department of the Army 2008), Chapter 22, "Army Energy and Water Management Program." Reclaimed or recycled water should be used for landscape irrigation unless specifically excluded.
- AR 420-1. Chapter 23, "Utility Services" establishes policy and criteria for the operation, maintenance, repair, and construction of distribution, collection, treatment, and disposal facilities for water supply, wastewater, stormwater, and industrial waste. Garrisons or installations with privatized water or wastewater systems will monitor contractual and regulatory compliance of utility providers, as required by their contracts.
- Where Life Cycle Cost results in a positive benefit, reclaimed or treated recycled water will be used for irrigation and other non-potable uses. Graywater or untreated effluent from laundry, dishwashing, and personal hygiene/bathing will not be recycled or reused as part of a U.S. Green Building Council (USGBC) sanctioned program for a LEED credit without approval from Installation Management Command.
- AR 200-1, *Environmental Protection and Enhancement* (Department of the Army 2007), states that Army activities will evaluate the use of innovative/alternative technologies for the treatment of wastewater.

Reclamation of treated wastewater for irrigation purposes in place of potable water supports this mandate.

- AR 200-3, *Natural Resources – Land, Forest and Wildlife Management* (Department of the Army 1995), requires a comprehensive approach in designing and maintaining the built environment to minimize as much as possible landscaped areas requiring irrigation and grounds maintenance. Native and low maintenance plants are preferred. Treated potable water will not be used to irrigate arid areas to create or maintain environments to grow non-arid plants. Irrigation in arid areas will be limited to select high visibility areas, or (where required) to maintain vegetative cover for a designated use (e.g., a golf course). The intent is to encourage water reuse, rainwater harvesting, rainfall sensor controls, and other techniques commonly used to increase irrigation efficiency. Creative and supportive policy development can support this intent.
- EISA 2007, section 438 led to an Army policy on Low Impact Development (LID), which promotes rainwater harvesting as one solution in the Army toolkit (Hammack 2010).
- The Installation Management Command's Campaign Plan Line of Effort 6, "Energy, Water Efficiency, and Security," Task EN1, reduced energy and water consumption, and Task EN2 increased energy and water efficiency and modernized infrastructure (Installation Management Command 2010)

LEED and the Green Building Initiative both encourage rainwater harvesting, e.g., LEED grants points for forms of water reuse and improved water efficiency. The USGBC updated the LEED ratings system to v2009 for new construction and major renovation. Among the many changes is an updated scoring system for water efficiency and conservation:

- Total water efficiency points have increased to 10.
- The Water Efficiency category has been expanded to include efficient landscape irrigation, innovative wastewater technologies, and water use reduction.
- The points available for indoor water efficiency have increased from 3 to 12 points.
- The Indoor Water Efficiency credit now includes a prerequisite mandating that all LEED projects hit a 20 percent water savings mark (as compared to a standard baseline).
- Water use reductions are now calculated based on the implementation of "strategies that in aggregate use 20 percent less water than the water

use baseline calculated for the building (not including irrigation)" (USGBC 2009).

- Points can be earned by reducing the use of potable water irrigation by 50 percent from a calculated mid-summer baseline.
- Irrigation use reductions "must be attributed to any combination of the following items: plant species, density and microclimate factor, irrigation efficiency, use of captured rainwater, use of recycled wastewater, use of water treated and conveyed by a public agency specifically for nonpotable uses" (USGBC 2009). Other points remain available in stormwater volume reduction and reduction of pollutants in stormwater.

Currently, the Army has no policies on whether to accept potable water produced or purchased for Army installations from direct or indirect recycling activities. The majority of states have primacy for oversight of the Safe Drinking Water Act and the Clean Water Act (CWA). For those states without primary responsibility, the USEPA continues to oversee the implementation of the SDWA and CWA. While this division of responsibility exists between the states and the USEPA, it does not consider the effect on military installations that receive water from local municipalities. These municipalities are regulated by state water agencies that have been delegated SDWA and CWA responsibility from the USEPA. Additionally, privatization has eliminated the Army's ability, in some cases, to control its acceptance of direct or indirect potable reuse water if that water was purchased from an off-site utility or whether or not to produce water that meets drinking water standards for their own direct reuse. Legislation or policy may be needed to clarify water rights opportunities that should remain with the Federal government, particularly military installations.

Difference between water reuse regulations and guidelines

Understanding the difference between regulations and guidelines is important. Whereas regulations are legally adopted, enforceable, and mandatory, guidelines are advisory, voluntary, and unenforceable, but when included in water reuse permits become enforceable requirements. Some states prefer the use of guidelines to provide flexibility in regulatory requirements depending on project-specific conditions, which can result in differing requirements for similar uses within a state and lead to inequities in water reuse permits if guidelines are not uniformly imposed. As reclaimed water becomes more common in states having guidelines, one can expect that regulations will eventually be adopted.

Water reclamation and reuse in the United States are not addressed by Federal regulations , regulations or guidelines are developed and implemented at the state level. The lack of Federal regulations has resulted in differing standards among states that have developed water reuse regulations. At present, no states have regulations that cover all potential uses of reclaimed water, but several states have extensive regulations that prescribe requirements for a wide range of end uses of reclaimed water. Other states have regulations or guidelines that focus on land treatment of wastewater effluent emphasizing additional treatment or effluent disposal rather than beneficial reuse even though the effluent may be used for irrigating agricultural plots or public access lands, i.e., property where the general public may enter, such as golf courses or parks. Where there are no regulations or guidelines, regulatory agencies may prescribe requirements case-by-case. In such cases, it should be assumed that proposed uses not covered in a particular state's standards will be prohibited. No states include criteria for all potential reclaimed water applications, and with some exceptions, such as direct potable reuse, regulatory agencies are likely to consider uses not currently regulated.

Water reuse regulations focus on public health and environmental implications of using the water. For non-potable reuse applications, criteria principally are directed at reducing or eliminating pathogenic microorganisms, whereas criteria for potable reuse address both microbial and chemical constituents. Water quality criteria not related to health or environmental protection are not usually included in water reuse regulations. States that have water reuse regulations or guidelines typically prescribe treatment unit processes in addition to water quality requirements, although a few states, such as Texas and New Mexico, do not prescribe treatment processes and rely solely on water quality limits. Many state reuse regulations include requirements for treatment reliability and use area control. Water reuse regulations usually allow for alternative methods of treatment not specified in the criteria if alternative treatment methods are approved as satisfactory by a regulatory agency that is equivalent, in terms of treatment performance and reliability, to those prescribed in the regulations. States may require extensive operational data for new or innovative alternative treatment processes. Pilot plant or demonstration studies may be necessary to validate proposed alternative treatment processes. There is a wide variability in state water quality and treatment requirements for non-potable reuse applications.

Factors and constituents that affect water reuse regulations/guidelines

Water reuse regulations and guidelines are based on a variety of considerations (Table 2). The public health is protected by eliminating or reducing the concentrations of health-significant microbial and chemical constituents through wastewater treatment and/or by limiting public or worker exposure to the water via design and operational controls. Several constituents in untreated wastewater could present health or environmental risks if not reduced in concentration or eliminated. These constituents may be directly or indirectly subject to regulatory controls when reclaimed water is used for beneficial purposes.

Table 2. Factors affecting water reuse regulations.

Factor	Description
Public Health protection	Water reuse guidelines and regulations are directed principally at public health protection. For non-potable reclaimed water applications, criteria generally address only microbiological and environmental concerns. Health risks associated with both pathogenic micro-organisms and chemical constituents must be addressed where reclaimed water is to be used for potable water supply augmentation.
Use area controls	Reclaimed water quality requirements are based on proper controls and safety precautions implemented at areas where the water is used. Depending on reclaimed water quality and type of use, controls may include warning signs, color-coded pipes and appurtenances, fencing, confinement of the water to approved areas of use, cross-connection control provisions, and other public health protection measures.
Use requirements	Many industrial uses and some other applications have specific physical and chemical water quality requirements that are not related to health considerations. Similarly, the effect of individual constituents on crops or other vegetation, soil, and groundwater or other receiving water is an important consideration for reclaimed water irrigation applications. Physical, chemical, and/or microbiological quality may limit user or regulatory acceptability of reclaimed water for specific uses. Water quality requirements not associated with public health or environmental protection are seldom included in water reuse criteria by regulatory agencies.
Environmental considerations	The natural flora and fauna in and around reclaimed water use areas and receiving water should not be adversely affected by reclaimed water.
Economics	Although regulatory agencies take into account the costs that regulations impose on reclaimed water producers and users, they are prone to set standards thought to be safe and do not lower health or environmental standards for the sole purpose of making projects economically attractive.
Aesthetics	For high-level non-potable uses, e.g., urban irrigation and toilet flushing, the reclaimed water should be no different in appearance from potable water, e.g., clear, colorless, and odorless. For recreational impoundments, reclaimed water should not promote algal growth.
Political realities	Regulatory decisions regarding water reclamation and reuse may be influenced by public policy, public acceptance, technical feasibility, and financial considerations

From (Holliman et al. 2009).

Microbiological constituents of concern in water reclamation and reuse include bacteria, protozoa, helminthes, and viruses. Chemical constituents of concern include biodegradable organics, total organic carbon, nitrates, heavy metals, pH, trace constituents, disinfection byproducts, and total dissolved solids. Physical properties of concern are turbidity, total suspended solids, and temperature.

Potable Reuse

Indirect potable reuse

The United States has no direct potable reuse projects. No state has developed regulations allowing such use although extensive discussions are ongoing within state professional associations and various health agencies. A few states have adopted criteria for indirect potable reuse of reclaimed water. California, which has the greatest number of existing indirect potable reuse projects in the United States, has draft groundwater recharge regulations, whereas other states have adopted regulations for groundwater recharge or both groundwater recharge and surface water augmentation.

Criteria for indirect potable reuse include stringent treatment and quality criteria. Some of the other states rely on the USEPA's Underground Injected Control (Holliman 2009) regulations to protect potable groundwater basins, whereas some states prohibit indirect potable reuse altogether. In some states, regulations addressing indirect potable reuse are independent from the state's water reuse regulations. For example, the use of reclaimed water for groundwater recharge in Arizona is regulated under statutes and administrative rules administered by the Arizona Department of Environmental Quality and the Arizona Department of Water Resources.

No Federal regulations specifically address reclaimed water reuse. Proposals to recharge groundwater by either surface spreading or injection in California are evaluated case-by-case, although currently existing draft groundwater recharge regulations guide decisions. Product water, the water produced during the specific wastewater reclamation treatment process train, to be recharged must meet all primary drinking water standards and must be monitored for other constituents of concern in addition to numerous other requirements. Florida has adopted similar reclaimed water treatment and quality requirements.

Direct potable reuse

The key difference between indirect and direct potable reuse is that there is no temporal or spatial separation between the introduction of the reclaimed or recycled water and distribution as drinking water. The environmental buffer that precedes normal drinking water treatment is eliminated. The environmental buffer provides mixing, dilution, natural processes (such as sunlight disinfection or adsorption to particulates), filtration, and time for corrective action.

Planned indirect potable reuse has been practiced for decades (and with increasing frequency) in the form of surface spreading, direct injection, or addition upstream of a water treatment plant. However, direct potable reuse is still controversial in many ways even as technology makes it possible. To date, no regulations or criteria have been developed or proposed. It has generally been deemed unacceptable by health regulators despite advances in treatment technology and monitoring, data from existing indirect projects, and data from the limited number of direct potable demonstrations and projects.

Issues for direct potable reuse include:

- definition of direct potable reuse
- compensation for loss of an environmental buffer
- multiple barriers
- dilution
- constituents of concern and monitoring
- assessment of health risks
- applicability of regulations
- regulatory responsibility
- development of a communication system among agencies.

Other concerns related to direct potable reuse include regulatory requirements, health concerns, facility operation and management, and consumer perception. On the positive side, direct potable reuse can potentially address supply needs in water-scarce areas; provide greater flexibility; and provide potential environmental benefits. For example, perhaps the best known and most studied direct potable reuse system in the world exists in Windhoek, Namibia (Lahnsteiner and Lempert 2010). The system supplies a substantial portion of the local potable water supply. Water is treated through a complex and redundant treatment process train, and through

blending before distribution. Extensive monitoring takes place during and following treatment.

Required safety assessments for direct potable reuse include:

- investigation of microbial and chemical quality of the product water
- evaluation of treatment performance and reliability
- consideration of multiple barriers
- determining local monitoring capability
- system operation and management.

Such safety assessments must be resolved by regulatory agencies during development of regulations, policies, and guidelines. The concept of multiple barriers is vital to quality. Typical multiple barriers consist of: source control programs; combination of treatment processes; design and operational procedures to rapidly detect abnormalities in treatment process performance; constituent monitoring, and environmental buffers. Ensuring the reliability of the product water through redundancy is an essential component if one or more treatment stages fail.

Advancements in treatment technology have contributed to a reappraisal of direct potable reuse. These advances include more effective and reliable advanced oxidation processes; advances in ultraviolet radiation for disinfection and other disinfection alternatives; and rapidly evolving analytical monitoring methods to detect trace organics. Recycled water quality data from numerous sources and programs around the country and the world have been shown to meet all drinking water standards.

Several health effects studies over the past 30 years (Crook 2010; Condie et al. 1994; Isaacson and Rauf 1988; Khan and Roser 2007; Lauer 1993; Lauer and Rogers 1998; National Research Council 1998) show that health risks associated with direct potable reuse are no greater than those that occur with the use of current water supplies (Anderson et al. 2010). It has been argued that there are limitations in techniques (Crook 2010); risk analysis and analytical technology can now detect much smaller levels of potentially harmful constituents. Some health experts suggest that, with multiple treatment barriers present, water quality criteria for constituents of concern are met, the chemical composition of the product water is well understood, and the need for toxicological characterization is low.

Real-time online monitoring is essential. There also needs to be a means for an immediate diversionary response to prevent release of water with unacceptable microbial quality.

New policy considerations

The subject of who should regulate waste water raises numerous questions, particularly when regulation varies by state. Is it water supply, wastewater treatment, or both? Is drinking water a beneficial use of recycled water? Will source water protection programs have to be established throughout a sewershed? Water rights issues are complex and vary state-by-state. Public health departments will be involved, along with other state agencies. Further complicating regulations is the lack of consistency between state and, Federal rules and programs, such as the surface water treatment rule; drinking water source assessment programs; and the concept of use of extremely impaired sources. Although draft regulations exist for groundwater recharge into potable aquifers in some states, they may need to be modified.

Most states have responsibility for regulating the Clean Water Act and Safe Drinking Water Act, but, these laws do not directly apply to potable reuse. No Federal regulations for direct potable reuse exist. Regulatory responsibilities include:

- approval of pollutant source control programs for wastewater collection systems
- issuance and enforcement of reclaimed water requirements to producers and users of recycled water
- regulation of operators of wastewater and water reclamation plants
- water rights determinations.

4 Examples of Water Reuse on Army Installations

Water reuse is already practiced on Army installations. Examples include vehicle washing, irrigation, cooling tower makeup, and aquifer recharge (Table 3). There is generally no controversy over the use of recycled water on Army installations. Where reclaimed water is available from nearby systems, installations show a willingness to accept and use this highly treated water on-site for irrigation and cooling tower makeup.

Currently, Army installations have a wide range of reuse. Water quality for the various reuses can also vary. For example, Fort Sam Houston, San Antonio, Texas, is connected to the San Antonio Water System's reuse pipeline and uses that highly treated reclaimed water for extensive irrigation and for cooling tower makeup. Major users of recycled water at many Army installations are their Central Vehicle Wash Facilities (CVWFs). Historically, the Army had problems cleaning its tactical vehicles after training exercises. The process required considerable time and large amounts of water. Large CVWFs are designed and used to centrally wash tracked vehicles, such as tanks and wheeled vehicles, such as trucks.

Under adverse conditions, a large tank at a training facility may pick up 1 ton (approximately 1 cu yd), of sediment. To clean a tank the old way using hoses could take hours. However, the CVWF consists of a rugged "birdbath" with concrete "rumble strips" on the bottom that shake sediment loose, and water cannons that blast sediment away. Finer cleaning of the vehicle takes place after it emerges from the birdbath. Overall, the process realizes substantial savings in both time and manpower. The water is recycled through a sedimentation basin, with grit chamber and oil skimmer, sand filter, and holding pond. This process save 1 million gallons per day at a large facility, a substantial portion of total water use for an installation.

At Fort Carson, Colorado, the recycle system (Figure 1) includes a water storage capacity of 10 million gal and a treatment scheme that includes grit chamber, sand filters, oil skimmers, and aeration basins. Fort Carson estimates that its CVWF saves 150–200 million gal per year in potable water (Headquarters, U.S. Army Corps of Engineers 2008). This successful design has been copied at more than 25 Army installations.

Table 3. Water reuse categories and typical applications.

Category	Typical Application
Irrigation	Parks School yards Highway medians Golf courses Cemeteries Parade grounds Athletic fields Building landscapes Crops or vegetable gardens
Industrial recycling and reuse	Cooling water Boiler feed Process water Construction
Groundwater recharge	Groundwater recharge Saltwater intrusion control Subsidence control
Recreational/environmental uses	Lakes and ponds Marsh enhancement Streamflow augmentation Fisheries
Non-potable urban uses	Fire protection Air conditioning Toilet flushing Water features

Figure 1. Central vehicle wash facility Fort Carson, Colorado.

Fort Huachuca, Arizona, actively recharges highly treated effluent into infiltration basins, which support local environmental needs and recharge local aquifers. The installation has also been installing French drains that capture roof runoff to infiltrate into the ground, recharging the local aquifer.

Installations have expressed increasing interest in rainwater harvesting. However, changes are needed in construction codes and requests for proposals to mandate that contractors use that option more frequently in the future. EISA Section 438 is requiring the use of low impact development measures to be used on Federal facilities to retain more water on-site. Beneficially using this captured water for numerous purposes is actively being investigated. Options include irrigation, toilet flushing, cooling tower makeup water, water features, and vehicle washing. Plumbing codes are also being changed to actively promote the use of rainwater harvesting and graywater reuse where appropriate and feasible.

5 Ecosystem Services

The White House Climate Change Task Force has directed Federal agencies to apply ecosystem-based approaches. Where appropriate, adaptation should take into account strategies to increase ecosystem resilience and protect critical ecosystem services that humans depend on to reduce vulnerability of human and natural systems to climate change.

A broad definition of ecosystem services is presented limited only by the requirement of a direct or indirect contribution to human well-being. A variety of pathways recognize the many ways ecosystems support human life and contribute to human well-being. The Millennium Ecosystem Assessment (2005) categorizes ecosystem services as follows:

- *Provisioning services*. These are services from products obtained from ecosystems. These products include food, fuel, fiber, biochemicals, genetic resources, and fresh water. Many, but not all of these are traded in markets.
- *Regulating services*. These services are received from the regulation of ecosystem processes. This category includes services that improve human well-being by regulating the environment in which people live. These services include flood protection, human disease regulation, water purification, air quality maintenance, pollination, pest control, and climate control. These services are not marketed, but many have clear value to society.
- *Cultural services*. These are services that contribute to the cultural, spiritual, and aesthetic dimensions of people's well-being. They also contribute to establishing a sense of place.
- *Supporting services*. These services maintain basic ecosystem processes and functions such as soil formation, primary productivity, biogeochemistry, and provisioning of habitat. These services affect human well-being indirectly by maintaining processes necessary for provisioning, regulating, and cultural services.

Water reuse can contribute to all of these categories on and off an installation. Water reuse contributes to watershed protection or restoration. It also helps to preserve natural infrastructure. Benefits of water reuse include positive changes to water quality, water quantity, and support of ecological communities. Water reuse will also affect surface water by making more water potentially available, improving periodicity, and maintaining mini-

mum flows, which benefit flora and fauna. Water reuse will lessen extreme variability in water availability, and thereby improve biodiversity and habitat for threatened and endangered species.

Subsurface water will be affected by providing increased availability to domestic and industrial users. Availability will be increased because percolation and subsurface recharge will be enhanced through the additional flow. Maintenance of wetlands can be improved. Habitats that depend on the water table or subsurface flow will be enhanced because natural percolation and recharge processes will be maintained.

Water quality will be improved. Increased flows will dilute concentrations of organic and inorganic pollutants. Increased stream flows will also permit greater opportunity for the assimilation of biological materials.

Biological communities will also benefit. Habitats that depend on increased water quantities in a watershed and containing protected species will have a greater chance of long-term persistence. Increased water quantity and more uniform stream flows will support regionally important ecological communities, e.g., in-stream communities, bottomland forests, or wet prairies, thus maintaining specific habitats.

6 Summary

In the future, some Army installations may face water shortage, which may limit the Army's ability to execute its stateside missions. Water reuse and wastewater recycling are essential strategies to alleviate water scarcity and reduce the use of potable water. Where new water is at a premium, reused water may help to remove water as the limiting resource.

The Army is promoting water reuse and already uses recycled wastewater in such applications as irrigation, dust control, and vehicle washing, aquifer recharge, cooling tower makeup, environmental purposes, and industrial processes. Other water recycling and reuse strategies are under development. However, despite requirements mandating increased water efficiency and water conservation, potable water consumption is not being reduced; additional water reuse is needed.

The Army is investigating additional ways to encourage water reuse and to determine what kinds of water reuse policies may be needed. Demonstrations of water reuse e.g., rainwater harvesting and graywater use, must be conducted to show garrisons, Army master planners, facility engineers, and others that such water reuse technologies are feasible, practical, and economical, and that they work. The increased applications of such technologies will result in substantial cost reductions as contractors are encouraged and pushed to perform at better than the minimal level of effort in meeting LEED standards, e.g., a contractor can meet the minimal LEED standards just through the use of low-flow fixtures.

The Army Sustainability Campaign Plan is an excellent beginning; the suggestions presented within it could technically be adapted immediately into policy to support a more water-efficient Army less restricted by water availability. The Army Energy Security Implementation Strategy Plan (Office of the Deputy Assistant Secretary of the Army 2009) is another excellent beginning.

Water reuse can also enhance ecosystem services. Water reuse can contribute to watershed protection and restoration of both surface and subsurface water resources. Water reuse will allow more of the available water resources to be used to support current mission(s), to support ecological communities, and also to provide supplementary water, which will support

biological communities. Water reuse also supports the Army's Net Zero Installation program by providing alternatives for efficient water use on installations.

7 Recommendations

The Army should not develop a *direct* water reuse policy that mandates its implementation because of the many unanswered questions about its acceptability and how individual and potentially conflicting state regulations would affect a unified Army water reuse policy. The Army, through the network of Regional Energy and Environmental Centers, should monitor what individual bellwether states of California, Florida, Texas, and Arizona are doing concerning direct water reuse and track issues of direct water reuse raised by the water reuse community.

Policy should be issued directing water reuse in new construction and rehabilitation projects. Explicit policy already directs that low impact development be used. Perhaps more encouragement and "how to" examples will accelerate adoption.

There are significant policy concerns regarding *indirect* water reuse on Army installations. These issues include, how much, if any, control an installation should have over the quality of water delivered to the installation, and, the national security implications of water supply privatization and the delegation to the states of administration of the U.S. Environmental Protection Administration's National Pollutant Discharge Elimination System program.

If a providing utility practices indirect Army policy must address whether the installation needs to require additional treatment once it arrives on the installation, or should the Army accept state regulation of the water supply as being adequate to ensure Soldiers' and residents' safety? For those installations that maintain control of their water resources, Army policy should address the requirements for indirect reuse.

Water utility privatization has national security implications because of a non-Army entity has control over an installation's water supply. The long term viability of the utility and the physical distribution system itself should be a part of any consideration to privatize the water system. Disruptions in service, whether temporary or longer term, will restrict or prevent the ability of installation personnel from carrying out their mission, rendering the installation incapable of supporting the Army.

The USEPA's delegation of NPDES administration to the states would require an installation to seek state approval to implement indirect or direct water reuse programs. If an installation's overall water budget, particularly in those areas of the United States where future water supply may become problematic, e.g. areas of the desert West, water reuse programs may become a vital part for continued installation functionality in the face of declining water sources. Should installations accept the need to obtain state approval with the caveat that the installation seeks this approval only out of comity with the state? The Army and the USEPA should seek a formal understanding that makes explicit a national security op-out of the NPDES requirements in the narrow circumstance when using reused water becomes a critical option to maintain installation viability.

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14. ABSTRACT

In the future, some U.S. Army installations may face water shortages resulting from climate change, drought, reduced surface streams and aquifer levels, competing regional requirements for agriculture, municipal consumption, energy production, and environmental requirements. This reduction in available water resources will threaten the Army's ability to execute its mission. Many Federal, Department of Defense (DOD), and Army policies, regulations, plans, and strategies have sought to address this problem by encouraging water conservation, efficiency, and reuse. Many states also promote or require water reuse. Where practical, the Army promotes and practices water reuse in a numerous ways, e.g., for irrigation, aquifer recharge, cooling tower makeup, environmental purposes, vehicle washing, and industrial uses. Despite these efforts, Army water consumption is not decreasing. Water reuse and wastewater recycling are ways to reduce scarcity problems and reduce use of potable water. There is a need for additional ways, including policy changes, to encourage these conservation practices. This report explores current and potential water reuse and wastewater recycling in the Army (including applicable laws and regulations, differences between regulations and guidelines, potable reuse considerations, and examples of water reuse at installations), and makes recommendations for policy changes that will increase water reuse on Army installations.

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